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what he perceived was mainly the thoroughgoing causal integration of its whole content. That this perception brought with it a tremendous feeling of importance and superiority is a matter of course.

I have treated the phenomenon under discussion as if it consisted in the uncovering of tracts of *consciousness.* Is the consciousness already there waiting to be uncovered? and is it a veridical revelation of reality? These are questions on which I do not touch. In the subjects of the experience the "emotion of conviction" is always strong, and sometimes absolute. The ordinary psychologist disposes of the phenomenon under the conveniently "scientific" head of *petit mal,* if not of "bosh" or "rubbish." But we know so little of the noetic value of abnormal mental states of any kind that in my own opinion we had better keep an open mind and collect facts sympathetically for a long time to come. We shall not *understand* these alterations of consciousness either in this generation or in the next.

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SOME NEGLECTED PARADOXES OF VISUAL SPACE. III

POWERFUL influences have been driving most philosophical discussions of space and time into the narrow and, in my opinion, errant grooves of geometry and psychologistic biology. Beginning with his space concepts, for instance, the geometer so manipulates them, intentionally in a pure deduction, that their ultimate meaning is paradox and paradox. Likewise the biologist: he sets out with sensations and perceptions of space and, trying to find them over again in the very same spatial universe where these experiences have grown up, ends perforce in a muddle. That something may have been gained by both investigators, nobody need doubt; but the meager and irregular returns of their investment of strenuosity encourage the philosopher to strike from another angle. The following remarks would do just this. They should be looked upon as an experiment, to be judged entirely by its fruits.

I am again going to look at space, neither as a geometer nor as a psychologist of the schools. I shall not deduce the implications of certain Euclidean or non-Euclidean concepts of extension, direction, position, magnitude, etc., nor shall I inquire into the upbuilding of space *qualia* into space concepts. I shall only accept the natural space-world—the world that all ordinary persons somehow or other have come to rely upon—and, secondly, the adaptive, self-changing, specializing nervous organism, as it is known in its broader outlines and behavior to modern biology. And I shall then ask about two striking peculiarities of this organism's adaptation to this extended world in which it must find itself: first, about the correspondence of spatial form between the retinal image of a perceived thing and the thing perceived; then about the vastly more important reflex imitation. The constant purpose, in each case, will be to discover whether an organism would be more likely to develop as our own actually have in a world which stretches out essentially as we think our world does or in a world whose spaces are all forms of consciousness —or, as I prefer to put the Kantian thought, hyperchemisms. However otiose this purpose may seem to professional epistemologists, it can not but loom large to any biologist who, be it with Driesch and Wolff or with Pauly and Francée, looks ahead to the horizon of his science, where the philosopher's sky comes down to meet it. For, if organic differentiations, particularly those involved in the development of perceptions of and reactions to visual space, can not be explained on the Kantian hypothesis of hyperchemistry, then every biologist faces a momentous dilemma. Either he must cling to the idealistic hypothesis about space, following Driesch, and cast out, root and branch, every principle of ontogenetic and phylogenetic explanation which in any wise involves the notion of spatial adaptation to a genuinely spatial environment; or else, retaining this notion and its derivative explanations, he must winnow from his faith and his literature the reams of idealistic epistemology which, through Mach, Pearson, and many other scientists, he has borrowed from a century-old metaphysic. One need not be versed in any science in order to sense the wide, long consequences of accepting squarely either alternative. The better part of theoretical biology, and not a little of similar flights in many other fields, would have to be done over again, were the dilemma accepted.

I. *Retinal Image and Perceived Form*

One of the first tricks which poor little sophomores are taught, after falling into the hands of the psychologist, is to regard as a most unhappy accident the correspondence of form between the (miscalled) retinal image and the thing seen as the result of that image's presence. "What you see," says the teacher, "has no such immediate connection with the ether vibrations which strike the periphery of your optic tract. It is some kind of nerve current which you really come to know when it gets to your cortex and does something there." And then Thomas Brown is cited. "If," he has written in his Lectures, "this (the shape of the nervous expanse affected peripherally) alone were necessary, we should have square inches and half-inches and various other forms, rectilinear and curvilinear, of fragrance and sound." And, to drive the point home, Professor James's lucid foot-note ("Principles of Psychology," II., 144) has the last say. It represents the almost unanimous conviction of contemporary psychologists and philosophers so accurately that it must be quoted.

> "In the matter of *spatial* feeling, . . . it looks at first sight as if the sensation might be a direct cognition of its own neural condition. Were this true, however, our sensation should be one of *multitude* rather than of continuous extent; for the condition is *number* of optical nerve-termini, and even this is only a remote condition and not an immediate condition. The immediate condition of the feeling is not the process in the retina, but the process in the brain; and the process in the brain may, for aught we know, be as unlike a triangle (the figure used in a previous illustration),—nay, it probably is so,—as it is unlike redness or rage. It is simply a *coincidence* that in the case of space one of the organic conditions . . . should lead to a representation in the mind of the subject observed similar to that which it produces in the psychological observer. In no other case is the coincidence found. Even should we admit that we cognize triangles in space because of our immediate cognition of the triangular shape ot our excited group of nerve-tips, the matter would hardly be more transparent, for the mystery would still remain, why are we so much better cognizant of triangles on our finger-tips than on the nerve-tips of our back, on our eye than on our ear, and on any of these parts than in our brain?"

Straining to its highest tension my frail will to believe, I have been able to detect not the slightest plausibility in all this, probably because I suffer from congenital realism. Laboring under the infirmities of this disease, though, I fancy I discern there three or four contentions profoundly opposed, in spirit if not in word, to thoroughgoing realism. And, as I am here trying out such a realism on the stubborner facts of space, its objections to Professor James's note must find voice.

1. It is not true that, if a percept were somehow a mental copy of the pattern of ether waves at the retina, multitude should be the thing or character perceived. For, if we follow the usual hypothesis and say that each rod and cone yields a sensation of extension, clearly we must admit (1) that the space between rods and cones is visually non-existent and hence can not form a visible gap between the sensed spaces; and (2) that no primordial extension quale, such as any single rod or cone delivers, can possibly contain empirically an awareness of its own spatial limits, but must be absolutely boundless, when viewed from inside, as it were, or by itself. To do justice to this objection to Professor James's point I must refer the reader to two previous articles in this series (this JOURNAL, Vol. VI., Nos. 22 and 24). I would urge, as a result of these studies, that the continuous extent whose presence encourages Professor James and almost everybody else to discredit the retinal image is absolutely no evidence against the latter. For every totality of simul-

taneously given extensions is, one might say, by definition a space continuum just because it consists of *all* given spaces. To suppose that *all given* spaces could be given as separate space-points is not even a possible hypothesis, but a downright contradiction; inasmuch as a given separateness is a given externality, in short a given space intervening between given space-points. Though this may sound in some ears like dialectic, I am confident that it is nothing more harmful than accurate description and loyalty to definitions where loyalty is needed for the description's sake.

2. The number of nerve-termini is not the essential condition determining the form of the retinal image, though of course it is influential in various ways. Relative position is what counts. Indefinitely many different sets of nerve-termini can be the means of yielding the same perceived form. What would be the smallest group capable of producing, say, an empirical triangle, we do not know; the behavior of *minima visibilia* in human perception makes probable that fully a dozen termini must normally be involved, and maybe twice as many. I can conceive, though, of a retina so perfectly organized that six or seven rods would do the business, and without involving any structure or function radically different from those of the human. But this is beside the point; the crux is in distinguishing the retinal determinants of perceived form from those of perceived size. The former owe their efficiency to some kind of active cross-relation—call it synthesis, if you will, provided you do not invoke some spook, like the ego, to explain it. Though all direct evidence is lacking, there is a reasonable probability that either the horizontal cells or the immensely numerous lateral fibers in the retina make known visual forms; at all events, their presence and their position relative to the rods and cones suggest their connection with no other peculiarity of visual space. To be sure, the number of nerve-termini stimulated will generally influence the form perceived and, on the other hand, the perception of size always involves the formalizing or synthetic function. Indeed, on this second matter, I incline to go the extent of saying that all perception of number and size, excepting only the two limiting cases of a single *minimum visibile* and the total field of vision, is formalizing; that is, discrete points or masses can arise only as differentiations within a group. Even random dots on a sheet of paper can be numbered only in so far as the spaces between them are sensed *as* intervening, which is to say, *as* extension groups. But there is in all this absolutely nothing precluding or even resisting the notion that the number of nerve-termini affected only secondarily determines visual forms. If these very sketchy observations are enough to substantiate my point or even to make it entertainable, a serious objection drawn from introspec-

tion goes by the board. I refer to the fact that, in perception, forms do not vary with their size; thus, a triangle may double or quadruple its area without the slightest change of contour or geometrical integrity. Here the Kantian-Wundtian investigator sometimes thinks to find a powerful argument for two indispensable theories of idealistic psychology; (1) the "creative synthesis" and (2) the localization of this high function in the brain (usually the cortex). As a matter of fact, though, these questionable and ambiguous hypotheses can derive not the least support from that source except by ignoring histology and conceiving the retina, quite antiquely, as a sieve with pores or as a mere bundle of telegraph wires spread out at their ends and brought together as a cable in the optic nerve. But this brings me to the third objection.

3. "The immediate condition of the feeling," says Professor James, "is not the process in the retina, but the process in the brain"; and this, he adds, may no more resemble a triangle than redness does. His first point may be granted, at least in so far as the present topic is concerned; but please note that it has relevance to Professor James's argument only through the further assumption that the immediate condition, the brain process, does *not* consist, at least in part, of characters transmitted unchanged from the periphery. But it is precisely this assumption that constitutes the issue raised about the correspondence between retinal image and perceived form. To appeal to it is obviously to beg the whole question. Why should anybody suppose that the distribution and number of rods and cones stimulated do not peculiarly qualify the neural current—or whatever it is that gets to the brain—and that this current is so utterly different from the electric current that its features at the point of inception go lost altogether a few inches further up the conducting tract? The question has only two general answers. One is some metaphysical theory which makes every change of relation at a given center or node of relations modify all the characteristics of that center or node. The other—and the only one which any psychologist to-day will knowingly advance—consists of empirical evidences. So far as I have been able to understand these latter, however, they all are grounded upon the crudest histology and inaccurate descriptions of visual space.

To return to the independent variation of form-quality and size, this is evidence of "creative synthesis," in Wundt's sense, and of the central *locus* of this function only by the purest postulation; which is to say, only by assuming what you want to prove, namely, that some stratum of retinal neurons does not sense geometrical patterns. Maybe it does, and maybe again it doesn't; but you are not going to decide the question, for the biologist at least, by a mere say-so in favor of one opinion or the other. To say that you can not imagine how the retina could accomplish the feat is to aid or injure neither opinion; for if you object to immediate retinal synthesis because you can not think out its details, you must protest equally against synthesis in the cortex or by an ego. But, in a general way, retinal form-sensing appears to me a much less obscure process than that of any other visual function. For instance, may it not be that the horizontal cells sense the spatiality of the initial disturbances in rod and cone cells in a manner essentially analogous to that in which a magnetic field represents an electric field? The horizontal cell lies at right angles to the rod-cone cell system, even as the lines of magnetic force lie with respect to the electric current and its field. If, now, the ether vibrations are at bottom only a kind of electric disturbance, as physicists almost unanimously hold to-day, then we picture the retinal process quite comprehensively by supposing, in accord with all psychologists, that the three accepted characteristics of the *forward drive* determine the peculiarities of the light and color, while the *lateral drive* gives the space quality.[1] Such a conception, I am sure, would greatly simplify our stock puzzles of visual perception: to name only two, it would at least make comprehensible the odd fact that, though we never sense color without extension, we do sense extension without color in extreme peripheral vision; and it would also be an adequate physical explanation of the still more curious fact that a peripheral stimulus which yields only a colorless extension when not moved across a retinal tract, develops a color *quale* upon the slightest lateral displacement.[2] But, above all else, it would serve our present desire by showing that visual space-forms behave exactly as magnetic field-patterns do, in so far as the latter do not *necessarily* vary with their size nor yet with the number of electric currents cutting across and determining them. Elementary experiments in the physical laboratory demonstrate this last fact; hence I need not repeat here in detail how, for instance, by adding new electric units in the proper manner to a given electromagnetic field (most easily, of course, to the exterior of the field rather than by interpolation), the intensity of the central (original) field grows, but its pattern of stress or tension lines remains substantially what it was at first. If, now, the magnetic field is the stimulus of the space-sensing neurons, its *intensity* determines the sensed *magnitude,* while its *pattern* determines the sensed *form.* And as the intensity may be increased either by increasing the number of electric units across the field or by increasing the electric force of the units already in the field, so too the sensed magnitude may be increased either by increasing the number of rods and cones stimulated and communicating laterally with a given horizontal cell or else by increasing the stimulus in the rods and cones already involved. This second case, you will observe, roughly covers the phenomena of irradiation and possibly many illusions of size, particularly pathological macropsia and micropsia.

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[1] My use of the word "drive" implies no hypothesis of ether displacement. "Stress," "tension," or "potential energy" would do as well. Whether electromagnetic phenomena are genuine ether motions or something else is irrelevant to the present hypothesis; the two essential and, I believe, undisputed points are (1) the relative direction of electric and their accompanying magnetic forces, and (2) the correlation of the two forces (every electric current sets up a magnetic field, and every magnetic field, when moved, sets up an electric current).

[2] To clarify these and all other interpretations springing from the hypothesis is a hard undertaking which can not be entered upon here. All that I would do here is to suggest enough about the bearings of the hypothesis so that it will not seem a "long shot" or a momentary flash of scientific fancy. I hope, in the near future, to read off in its terms a large number of established and obscure psychological facts. Whether it will stand or not, it is the *kind* of interpretation wanted.

Though I believe the above hypothesis gives the clue to an explanation of space vision, I do not argue it here. It may be quite wrong. I cite it merely to show the easy conceivability of putting all fundamental qualities of seen space in the peripheral sense organs. And, be it recalled, my motive in showing this much is to forestall an overhasty appeal to central synthesis or to *a priori* forms of experience. To attribute to such transcendent functions or entities the moulding of psychic complexes which indubitably *seem* to be given no less objectively than sunlight is—to do this, I say, before having tried to correlate those complexes with well-authenticated, observable differences in stimuli and in peripheral structure, may be pleasant metaphysics, but it is assuredly bad scientific method. A grosser violation of the law of parsimony there could scarcely be.

4. Genetic psychology has advanced so far, since Professor James's classic "Principles" first appeared, that his last objection to the correspondence between retinal image and perceived form probably is less generally approved than it once was. Professor James himself may, for aught I know, long since have stricken it from his platform. I shall consider it here, though, because it introduces us gradually to the supreme issue which the following study of reflex-imitation grazes, namely, the controversy over the prior right of psychology or of biology to found our theories of reality and conduct. "Grant," says the psychologist, "that the eye does cognize retinal patterns. The mystery is as deep as ever. Why, as Professor James puts it, are we so much better cognizant of triangles on our finger-tips than on our back, on our eye than on our ear? And why, as Thomas Brown puts it, do we not smell octagons and hear tetra-

hedrons?'' These are provincial queries, difficulties which arise only if one refuses to look beyond the traditional confines of psychology for answer to problems within them. One glance at biology and its concepts of evolution makes nonsense of such doubts. No matter what or why or how evolution is, in any case it can readily account for the absence of square odors and curving sounds from human experience. Indeed, it makes them vastly more intelligible in their missing than in their appearance. The sense of touch is, by pretty general acceptance, the primordial one and, as will be pointed out more fully later, its earliest development seems to have been toward a space sense. From the naturalistic point of view, this was a first exigency, inasmuch as the sensitive organism lived in a really extended world to whose spatially marked differences it had to adjust itself. The organic medium of sensitivity of space had to develop at the point of contact with alien spaces, but nowhere else; hence the more or less distinct feelings of extent and position from all stimuli of the body's surface (including the alimentary canal) and the pretty uniform absence or exceeding vagueness of such feelings in connection with stimuli beginning anywhere inside one's skin. To the biologist, this cleavage suggests the thoroughly objective nature of space, though not necessarily a ''copy theory'' about our experiences of space. But—what concerns us much more deeply here—the common spatiality of peripheral sense-products, far from rendering more likely the same development of space *qualia* in all specialized sense organs, makes this outcome the least probable of all, under any evolutionary hypothesis whatsoever. We should expect one or two organs to grow toward the more complete knowing of space structures, while another attunes itself to one peculiarity of matter, another to some other cosmic character, and so on. Allow the right of such anticipation, and the correspondence between retinal image and perceived form shows up as no odd accident, but rather as a step toward more perfect representation of its environment by an organism; and the absence of a correspondence between the geometrical pattern of auditory nerve-termini and the harmonious sound they yield only confirms superfluously what we all know, to wit, that the basilar membrane, and its colleague neurons, are engaged in selecting and reacting to some cosmic peculiarity other than extension.

I do not believe many persons, even among those who deny the significance of the correspondence we have been considering, will hold out with Thomas Brown or Professor James against the biologists. It will be generally conceded that there is no mystery in a specialist knowing space as lay brethren know it not. But, unfortunately, the biologists' contention, granted in such trifling matters, is ignored in the greater issues. ''Perhaps,'' says the psychologist, "Darwin and his clan can force me with their principles to grant my eyes unique space-sensing powers. But by that they have not wrung from me a confession that the spaces I perceive exist apart from my nerves. If my friend, Smith, can turn his ophthalmoscope into my eye and detect there an image having a shape like the shape of the object I am at the same instant perceiving, that indicates only that, for the sake of the more accurate or the more useful *a priori* synthesis or mental creation, the spaceless vital force which is my self has so moulded itself—spacelessly, of course,—that one detail of its structure has one phenomenal quality somewhat like a quality concocted by my self in noumenal conjunction with *Ding an sich.*" Whether in this Koenigsberg jargon or not, almost every psychologist, not excepting those who pursue the genetic method, is to-day championing this intrinsically idealistic doctrine, while the more philosophical are explicitly denying, with lengthy proofs, that perception is, in *any* sense whatever, a copying function. So long as they stay at home dissecting their own minds, these thinkers get along passably. But when they crave, as all of them do, sooner or later, to know how their minds came to be what they are, and in the remarkable bodies they inhabit, they unhesitatingly fall back upon various principles such as "adaptation," "socialization," "differentiation," "natural selection," and the like. So be it. How can they do this, though, yet clinging to a belief in an unextended ego living in an unextended world? If space is not real, substantially as the ordinary man thinks it is, but a hyperchemical product of ego and world; and if the latter "elements" no more resemble space than oxygen and hydrogen do water, what and why is "adaptation," what the utility of inventing space with all its wearying distances, its inaccessible heights, perilous abysses and most vexatious antinomies? Men like Driesch and Bergson, scenting this danger from afar, have sought to meet it with a general metaphysical biology, which, like most ventures metaphysical, exhibits astounding skill in picking out facts that fit and overlooking most others. It is the realist's privilege, when, on metaphysical ground, to favor himself in the same liberal spirit. Out of scores of homely facts, therefore, I shall pick but two, the retinal image and reflex imitation, both especially convenient; and I shall inquire, in the next paper, how a psychologist can at the same time be an idealist in his theory of perception and any kind of an evolutionist in his theory of the origin and shaping of the organs of perception.

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